

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Number: 7,067,416 B2
Issued : June 27, 2006
Patentee : Ammar Derraa
Title : Method of Forming a Conducting Contact

CERTIFICATION OF SUBMISSION

I hereby certify that, on the date shown below, this correspondence is being transmitted via the Patent Electronic Filing System (EFS) addressed to Certificate of Correction at the U.S. Patent and Trademark Office.

Date: July 28, 2006 Ju L. Palmatter

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

ATTENTION: Certificate of Correction Branch

**REQUEST FOR CERTIFICATE OF CORRECTION OF PATENT
FOR PTO MISTAKE (37 C.F.R. SECTION 1.322(A))**

Sir:

It is requested that a Certificate of Correction be issued correcting printing errors appearing in the above-identified United States Patent.

Attached is Form PTO-1050, with the text of the Certificate in the suggested form suitable for printing.

The column and line number where the errors occur in the issued patent are as follows:

Column 13, line 20: Replace "through" with --throughout--.

Column 16, line 11: Replace "farm" with --form--.

Column 17, line 12: Replace "aver" with --over--.

Column 17, line 26: Replace "farming" with --forming--.

Column 17, line 42: Replace "aver" with --over--.

Column 18, lines 24-25: Replace "sidewalks" with --sidewalls--.

Column 18, line 45: Replace "sidewalks" with --sidewalls--.

Column 22, line 55: Replace "man" with --in an--.

Column 24, line 7: Replace "fanning" with --forming--.

Column 24, line 26: Replace "nurture" with --mixture--.

Column 24, line 59: Replace "500%" with --50%--.

REMARKS

The error sought to be corrected in the specification are Patent Office printing errors.

Supporting documentation includes a copy of the relevant pages from Applicant's Response (filed November 14, 2005), showing the original text to Claims 22, 51, 66, 67, 69, 117, 123, 127 and 129 (now renumbered as Claim 22, 52, 64, 65, 67, 88, 94, 98 and 100).

The requested correction is to correct a printing errors to conform with the specification and claims as allowed by the Examiner during prosecution. Issuance of a Certificate of Correction would not change either the scope or the meaning of the specification, and re-examination is not required.

As the errors listed are due to Patent Office printing mistakes, no fee is necessary in connection with this Certificate.

The Examiner is requested to contact the undersigned Attorney for Applicant should any questions arise with respect to this Request.

Please send the Certificate of Correction to:

Kristine M. Strodthoff
Whyte Hirschboeck Dudek S.C.
555 East Wells Street, Suite 1900
Milwaukee, WI 53202-3819

Dated: July 28, 2006

Kristine M Strodthoff
Kristine M. Strodthoff, Reg. No. 34259
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UNITED STATES PATENT AND TRADEMARK OFFICE CERTIFICATE OF CORRECTION

Page 1 of 1

PATENT NO. : 7,067,416 B2

APPLICATION NO.: 09/941,533

ISSUE DATE : June 27, 2006

INVENTOR(S) : Ammar Derraa

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 13, line 20: Replace "through" with --throughout--.
Column 16, line 11: Replace "farm" with --form--.
Column 17, line 12: Replace "aver" with --over--.
Column 17, line 26: Replace "farming" with --forming--.
Column 17, line 42: Replace "aver" with --over--.
Column 18, lines 24-25: Replace "sidewalks" with --sidewalls--.
Column 18, line 45: Replace "sidewalks" with --sidewalls--.
Column 22, line 55: Replace "man" with --in an--.
Column 24, line 7: Replace "fanning" with --forming--.
Column 24, line 26: Replace "nurture" with --mixture--.
Column 24, line 59: Replace "500%" with --50%--.

MAILING ADDRESS OF SENDER (Please do not use customer number below):

Whyte Hirschboeck Dudek S.C.
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Milwaukee, WI 53202

This collection of information is required by 37 CFR 1.322, 1.323, and 1.324. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1.0 hour to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Attention Certificate of Corrections Branch, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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PATENT

Attorney Docket No. MTI-31533

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : DERRAA, Ammar
Serial No. : 09/941,533
Filing Date : August 29, 2001
For : METHOD OF FORMING A CONDUCTIVE CONTACT
Group Art Unit: 2823
Examiner : FOURSON III, George R.
Confirmation No.: 4578

CERTIFICATION UNDER 37 CFR 1.8(a) and 1.10

I hereby certify that, on the date shown below, this correspondence is being transmitted to Fax
No. 571-273-8300 addressed to Examiner FOURSON at the US Patent and Trademark Office.

Date: 11-14-05 Rosa Strong 6590

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

RESPONSE

Sir:


Applicant requests consideration of the pending claims in the above-identified patent application based on the remarks herein.

Amendments to the Claims are reflected in the listing of the claims, which begins on page 2 of this paper.

Remarks begin on page 27 of this paper.

21. (original) The method of Claim 16, wherein the nitrogen-containing gas comprises ammonia.

22. (currently amended) A method of forming a conductive contact, comprising the steps of:
 depositing a source gas onto a substrate to form a fill having a thickness of about 500 angstroms or greater within a contact hole in the substrate; the source gas comprising TiCl_4 ;
 removing excess material from the substrate to form the conductive contact in the contact hole, ~~wherein~~ the conductive contact ~~has~~ having a thickness of about 500 angstroms or greater;
 and

 thermally annealing the conductive contact in a nitrogen-containing gas at a temperature of about 700°C . or greater to decrease chlorine ~~within~~ throughout the thickness of the conductive contact without forming substantial cracks within the conductive contact; the nitrogen-containing gas comprising ammonia.

23. (previously presented) The method of Claim 22, wherein the step of thermally annealing the contact comprises a rapid thermal anneal at about 700°C . to about 800°C .

24. (original) The method of Claim 22, wherein the source gas further comprises an ammonia precursor to form titanium nitride.

25. (original) The method of Claim 24, wherein the source gas further comprises a borane precursor to form boron-doped titanium nitride.

26. (currently amended) A method of forming a conductive contact, comprising the steps of:
 forming a titanium silicide layer over a substrate and within a contact hole;
 depositing a titanium nitride layer onto the titanium silicide layer to form a fill within the contact hole by combining a titanium and chlorine-containing precursor with a nitrogen-containing precursor to form a titanium nitride fill having a thickness of about 500 angstroms or greater;

50. (currently amended) A method of forming a conductive contact, comprising:
depositing a first source gas comprising TiCl_4 , H_2 , and SiH_4 precursors onto a substrate to form a titanium silicide layer in an opening;
depositing a second source gas comprising TiCl_4 , NH_3 , and B_2H_6 precursors onto the titanium silicide layer to form a boron-doped titanium nitride layer having a thickness of about 500 angstroms or greater within the opening;
removing excess of the boron-doped titanium nitride layer by chemical mechanical polishing while maintaining the boron-doped titanium nitride layer within the opening to form the conductive contact; the conductive contact having a concentration of chlorine and a thickness of about 500 angstroms or greater; and
exposing the conductive contact to a nitrogen-containing gas by thermal anneal at a temperature of about 700°C . or greater to reduce the concentration of chlorine throughout the thickness of the conductive contact without forming substantial cracks within the contact.
51. (original) The method of Claim 50, wherein the chlorine concentration of the thermally annealed conductive contact is less than about 3% by wt.
52. (currently amended) A method of forming a conductive contact in ~~a semiconductor device comprising an opening~~ through an insulative layer, the opening having sidewalls and extending to an underlying silicon-comprising substrate, the method comprising the steps of:
forming a layer comprising titanium silicide over the insulative layer and the substrate within the opening;
depositing a layer of boron-doped titanium nitride over the titanium silicide layer from a titanium and chlorine-containing precursor to fill the opening, the boron-doped titanium nitride fill layer having a thickness of about 500 angstroms or greater;
removing excess of the boron-doped titanium nitride fill layer overlying the insulative layer while leaving a portion of the boron-doped titanium nitride layer within the opening to form the conductive contact having a thickness of at least about 500 angstroms; and

66. (currently amended) A method of forming a conductive contact in an opening of a semiconductor substrate, the opening formed in an insulative layer and extending to an underlying silicon-comprising substrate, the opening defined by sidewalls and a bottom portion; the method comprising the steps of:

forming a layer comprising titanium silicide over the substrate and within the opening; and

depositing a boron-doped titanium nitride material over the titanium silicide layer and into the opening to form a fill having a thickness of about 500 angstroms or greater;

removing excess material from the substrate while leaving the boron-doped titanium nitride material fill in the opening to form the contact, wherein the contact has a thickness of about 500 angstroms or greater; and

heating the contact in a nitrogen-containing gas at a temperature of about 700°C. or greater to reduce the concentration of chlorine throughout the thickness of the contact to less than about 3% by wt. without forming substantial cracks within the contact;

wherein the conductive contact comprises an amount of boron to substantially eliminate peeling of the contact from the sidewall of the opening and cracking of the insulative layer, and an amount of nitrogen to provide an effective amount of conductivity to an active area within the substrate.

67. (currently amended) A method of forming a conductive contact in a semiconductor device comprising an opening through an insulative layer, the opening having sidewalls and extending to an underlying silicon-comprising substrate, the method comprising the steps of:

depositing a layer comprising titanium silicide over the insulative layer and the substrate within the opening; and

forming a titanium nitride layer over the titanium silicide by depositing a layer of titanium nitride over the titanium silicide layer; and sequentially depositing overlying layers of boron-doped titanium nitride and titanium nitride to fill the opening, wherein the boron-doped titanium nitride layer is interposed between two titanium nitride layers and the fill has a thickness of about 500 angstroms or greater;

69. (currently amended) A method of forming a semiconductor device, comprising the steps of:
forming an insulative layer over a silicon-comprising substrate comprising an active area;
forming an opening in the insulative layer to expose the active area of the substrate, the
opening having sidewalls;

forming a seed layer comprising titanium silicide over the insulative layer and the substrate within the opening; and

forming a layer comprising boron-doped titanium nitride over the seed layer to form a conductive fill within the opening;

removing excess fill material overlying the insulative layer ~~while leaving the~~ to form a conductive contact within the opening; the contact having a concentration of chlorine and a thickness of about 500 angstroms or greater; and

heating the conductive contact in a nitrogen-containing gas at a temperature of about 700°C. or greater to reduce the concentration of chlorine to less than about 3% by wt. without forming substantial cracks within the contact;

whereby the conductive contact comprises an amount of boron effective to provide the contact with a level of adhesion to the insulative layer within the opening to substantially eliminate peeling of the contact from the sidewalls of the opening, and a level of thermal stress to substantially eliminate cracking of the insulative layer; and an amount of nitrogen effective to maintain the conductivity of the contact at a predetermined level for an effective electrical contact with the active area.

70. (currently amended) A method of forming a semiconductor device, comprising the steps of:

forming an insulative layer over a silicon-comprising substrate comprising a conductive area;

forming an opening in the insulative layer to expose the conductive area of the substrate, the opening having sidewalls;

forming a seed layer comprising titanium silicide over the insulative layer and the substrate within the opening; and

heating the contact in a reactive gas at a temperature of about 700°C. or greater to reduce the chlorine concentration to less than about 4% by wt. throughout the contact without forming substantial cracks within the contact.

117. (currently amended) A method of forming a conductive contact in an opening in an insulative layer overlying a substrate, the opening having insulative sidewalls; the method comprising the steps of:

forming the conductive contact by depositing a gaseous mixture comprising titanium tetrachloride, ammonia and diborane into the opening, the conductive contact comprising a concentration of chlorine and having a thickness of about 500 angstroms or greater; and

heating the contact in a reactive gas at a temperature of about 700°C. or greater to reduce the chlorine concentration throughout the contact without forming substantial cracks within the contact;

wherein the contact comprises an amount of boron for effective adhesion of the contact to the insulative sidewalls of the opening to substantially eliminate peeling of the contact from the sidewalls and cracking of the insulative layer.

118. (previously presented) The method of Claim 117, wherein the contact comprises a level of nitrogen for an effective level of conductivity to an active area within the substrate.

119. (currently amended) A method of forming a conductive contact in an opening in an insulative layer, comprising the steps of:

depositing a gaseous mixture comprising titanium tetrachloride and ammonia within the opening to form a layer of titanium nitride;

depositing a gaseous mixture comprising titanium tetrachloride, ammonia and diborane within the opening to form a layer of titanium boronitride over the titanium nitride layer;

depositing a gaseous mixture comprising titanium tetrachloride and ammonia within the opening to form a layer of titanium nitride over the titanium boronitride layer;

heating the titanium boronitride layer in a reactive gas at a temperature of about 700°C. or greater to remove at least about 50% of the chlorine from throughout the titanium boronitride layer without forming substantial cracks within the titanium boronitride layer.

123. (currently amended) A method of forming a barrier layer on a substrate, comprising the steps of:

depositing a gaseous mixture comprising titanium tetrachloride, ammonia and diborane to form the barrier layer on the substrate, the barrier layer having a thickness of at least about 500 angstroms and a concentration of chlorine; and

heating the barrier layer in a reactive gas at a temperature of about 700°C. or greater to remove at least about 50% of the chlorine from throughout the barrier layer without forming substantial cracks within the barrier layer.

124. (previously presented) A method of forming a semiconductor device, comprising the steps of:

forming a layer of titanium nitride over a substrate, the titanium nitride layer having a thickness of at least about 500 angstroms and a concentration of chlorine;

heating the titanium nitride layer in a reactive gas at a temperature of about 700°C. or greater to remove at least about 50% of the chlorine from throughout the titanium nitride layer without forming substantial cracks within the titanium nitride layer; and

depositing a conductive layer over the titanium nitride layer.

125. (previously presented) The method of Claim 124, wherein the conductive layer comprises an interconnect.

126. (previously presented) The method of Claim 125, wherein the interconnect comprises aluminum.

127. (currently amended) A method of forming a semiconductor device, comprising the steps of:

depositing a gaseous mixture comprising titanium tetrachloride and ammonia on a substrate to form a layer of titanium nitride, the titanium nitride layer having a thickness of at least about 500 angstroms and a concentration of chlorine;

heating the titanium nitride layer in a reactive gas at a temperature of about 700°C. or greater to remove at least about 50% of the chlorine from throughout the titanium nitride layer without forming substantial cracks within the titanium nitride layer; and

depositing a conductive layer over the titanium nitride layer.

128. (currently amended) A method of forming a semiconductor device, comprising the steps of:

forming a layer of titanium boronitride over a substrate, the titanium boronitride layer having a thickness of at least about 500 angstroms and a concentration of chlorine; and

heating the titanium boronitride layer in a reactive gas at a temperature of about 700°C. or greater to remove at least about 50% by wt. of the chlorine from throughout the titanium boronitride layer without forming substantial cracks within the titanium boronitride layer; and

depositing a conductive layer over the titanium boronitride layer.

129. (currently amended) A method of forming a semiconductor device, comprising the steps of:

depositing a gaseous mixture comprising titanium tetrachloride, ammonia and diborane on a substrate to form a layer of titanium boronitride having a thickness of at least about 500 angstroms and a concentration of chlorine;

heating the titanium boronitride layer in a reactive gas at a temperature of about 700°C. or greater to remove at least about 50% by wt. of the chlorine from throughout the layer without forming substantial cracks within the titanium nitride layer; and

depositing a conductive layer over the titanium boronitride layer.